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Research Memorandum 2

VOICE TESTS ON MAN-PACK RADIOS IN A TROPICAL ENVIRONMENT

by

W. R. Vincent

Contract DA-36-039-AMC-00040(E)
Order No. 5384-PM-63-91(6109)
PR&C No. 63-ELNR-6109
Sponsored by ARPA
Order No. 371

SRI Project 4240

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Prepared for

United States Army Electronics Research and Development Laboratory
Fort Monmouth, New Jersey

STANFORD RESEARCH INSTITUTE

MENLO PARK, CALIFORNIA

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W. R. Vincent, Manager
Communication Laboratory

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VOICE TESTS ON MAN-PACK RADIOS IN A TROPICAL ENVIRONMENT

I INTRODUCTION

Under the direction of the Advanced Research Projects Agency and the United States Army Electronic Research and Development Laboratory, Stanford Research Institute conducted a field test program to compare the performance of selected man-pack radio sets under various tropical terrain and weather conditions. Initial steps had already been taken to establish a Tropical Communication Laboratory as part of the Combat Development and Test Center (CDTC) in Thailand. The formation of the basic laboratory and the assignment of personnel were hastened to accomplish the desired field tests.

This report describes the results of voice tests on the selected man-pack radio sets in a tropical forest environment. It will be followed by reports on the performance of the sets in other terrain environments.

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II DESCRIPTION OF THE TEST AREA

The need for prompt and immediate field tests of man-pack radio sets left little time for field site selection. Two tropical forest areas were considered: the Korat National Forest and the Bang Sapan area. Both areas contain relatively dense tropical forest useful for the field testing of man-pack radio sets. The Bang Sapan area was selected because of access by both road and railroad. A Bangkok businessman generously donated his hunting camp as a headquarters and living area, which greatly relieved housing problems. While improvements in living facilities were required, such as the construction of adequate cooking facilities, toilets, and showers, the hunting camp has proved entirely adequate. The location of the test area is shown in Fig. 1.

Small test station huts were constructed at sites 0, 5, 10, and 22 miles from the base camp shown on the map in Fig. 2. These huts were constructed of local material by local labor. They were placed in areas of dense ground vegetation, which was cleared for a few feet around each hut. All the huts are accessible by side roads. Some side road repair was necessary to prevent jeeps and trucks from scraping bottom; this was accomplished by local hand labor.

A slant-wire antenna was erected between the hut and a tree, with an elevation angle of about 30 degrees. The orientation of an antenna was generally in the direction most free of surrounding vegetation. Doublet antennas were erected between trees, about 25 feet above ground, generally broadside to the other test sites.

Adequate sites could not be found at 15 and 25 miles, because of conditions of terrain and lack of vegetation and of access roads.

Although the space between sites is largely forest area with dense undergrowth, there are occasional fields cleared for bananas and other tropical crops. The location of sites was based on visual aerial survey, to minimize the occurrence of cleared land between them. Figure 3 illustrates the general nature of vegetation in the test region. The

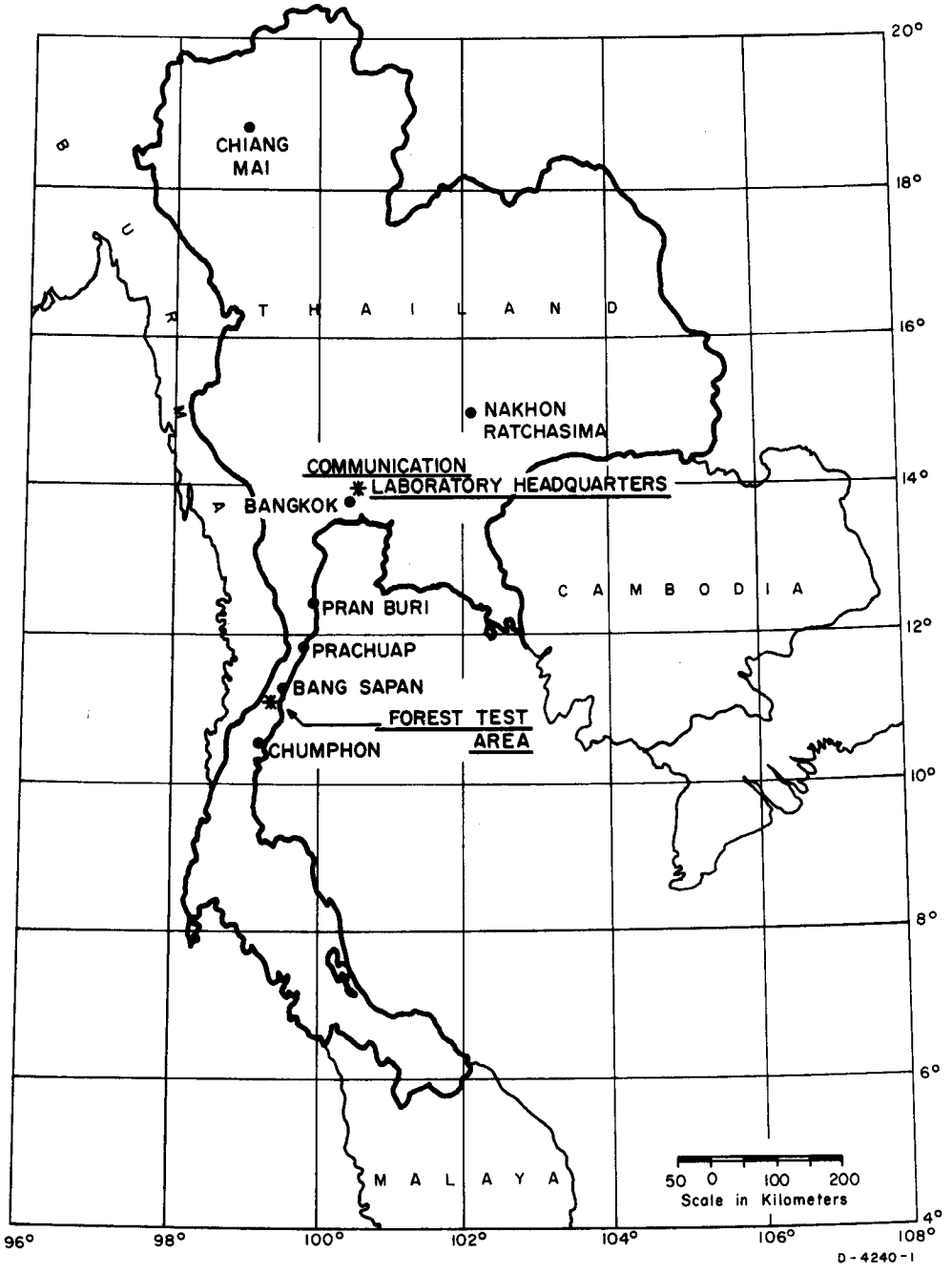

FIG. 1 MAP OF THAILAND SHOWING TEST AREA

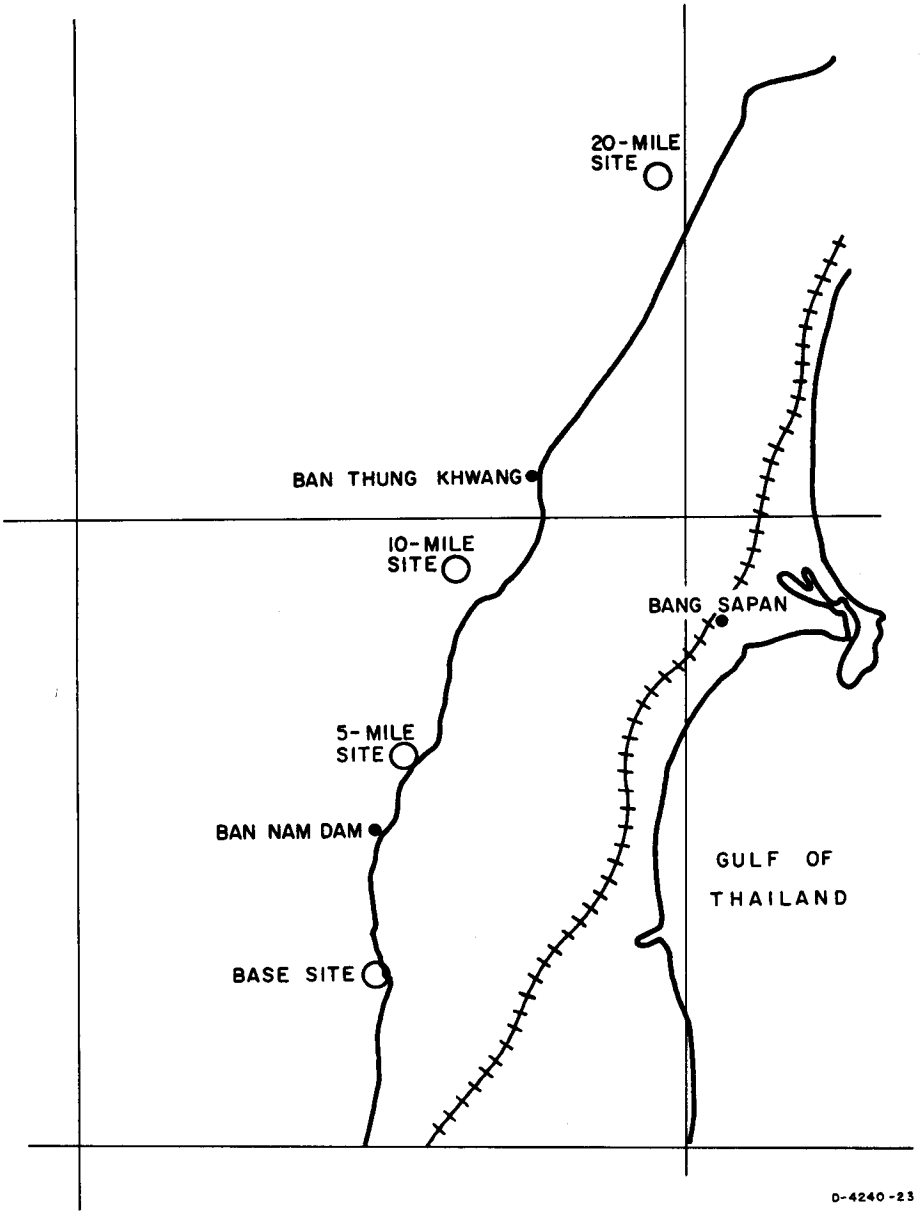

FIG. 2 MAP OF TEST AREA

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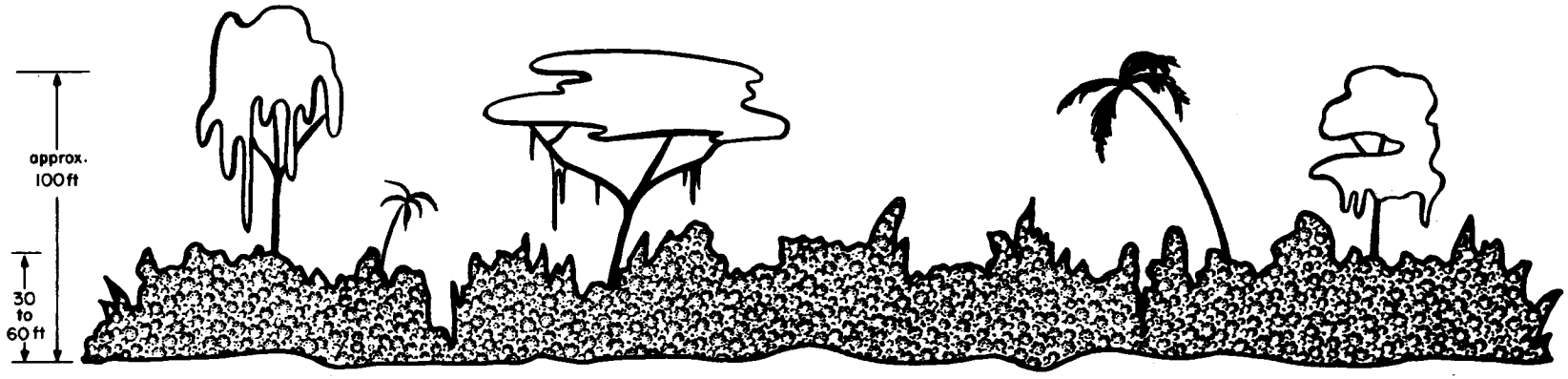

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FIG. 3 DIAGRAM SHOWING FOREST AND VEGETATION

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trees are very tall and generally at some distance from each other. The ground is densely covered with bamboo and other tropical plants. Since the ground vegetation extends upward for 25 to 40 feet, all antennas except the VHF whips were, for all practical purposes, immersed in the vegetation. No vegetation was allowed to touch an antenna wire

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III TEST CONDITIONS

The priority and emphasis placed on immediate testing of man-pack radio sets made it necessary to use many short cuts and abbreviated test procedures. Consequently, the tests, described in this memorandum have inadequacies and, to some extent, limited results. It is hoped that the conditions and limitations of the tests are so presented that the results can be adequately evaluated.

One each of the radio sets described in Table I (except for the experimental) were installed in a base hut at Site 0. Additional sets were moved from Site 1 to Sites 2 or 3, depending upon the range desired. A gasoline motor generator at each location provided power for battery charging, lights, auxiliary equipment, and other needs. Spare sets, spare batteries, and minor repair facilities were kept at the base camp, near Site 0.

The antennas required the first compromise. All sets were designed to operate with a slant-wire antenna. The AN/TRC-77 and -88 sets were not specifically designed to feed a doublet antenna. The AN/TRC-77 and -88 sets used the same slant-wire antenna kit; however, the HC-162 slant wire was somewhat different in design. Because of the late arrival of the HC-162 sets in Thailand, the slant wire for the AN/TRC-77 and -88 sets was installed in the field and was used for all sets. A doublet was cut to the test frequency and fed with a length of RG59/U coaxial cable to the dipole, because adequate matching transformers or baluns were not available, and seem not to be used in field military installations. The doublet feed coaxial cable was connected directly to the antenna terminals of the AN/TRC-77 and -88 sets and to the coaxial output of the HC-162 and TRP-4 sets.

Adequate test messages or word lists could not be assembled in time for the field tests. Consequently, random number lists, ten digits long, were employed as test messages. Although this closely approximates certain types of military messages, it can by no means be considered a comprehensive test.

GENERAL CHARACTE

RADIO SET	MANUFACTURER	WEIGHT (lb)	POWER OUTPUT	MODU-LATION	FREQUENCY RANGE (Mc)	NUMBER OF CHANNELS	BA PA (k
AN/TRC-77-AM	Sylvania	28	6-7 w	CW AM	3-8 Separate plug-in crystals for transmitting and receiving	6 Can be changed with plug-in crystals	5-
AN/TRC-88	Sylvania	27	10-14 w on CW 10 w on SSB	CW SSB FSK	3-8 Separate plug-in crystals for transmitting and receiving	6 Can be changed with plug-in crystals	5
TRP-4	Oki Radio	30	2 w	SSB	2.5-7.5	6 Can be changed with plug-in crystals	
HC-162	Hughes	20 or 25	15 w	CW SSB	2-11.99	Tunes to 1-kc increments from 2 to 12 Mc	2 at at
AN/PRC-25	RCA	17	1.5 w	FM	30-75.95 13 crystals	Continuous 50-kc increments	3
AN/PRC-35	RCA (Experimental model)	10	30 mw	FM	30-69.9 19 crystals	4 800 possible in 50-kc increments with crystals	4
AN/PRC-10	Admiral	--	1 w	FM	38-55	Continuous tuning	-

TABLE I

IERAL CHARACTERISTICS OF MAN-PACK RADIO SETS

JMBER OF HANNELS	BAND PASS (kc)	IF FREQUENCY	UNITS ON HAND	UNITS CAN BE RUN FROM VEHICLE	BATTERY INFORMATION	ANTENNA INFORMATION
6 be nged with g-in stals	5-6	455 kc	10	Yes on 12 v system	Rechargeable Voltage: 12 v Capacity: 4 ah Receiving current: 16 ma Transmitting current: 3.5-4 a Charge time: 4 hr using AC charger; 2 hr using DC charger (24 v) Weight: 16 lb Has 12 v external terminals for auxiliary equipment Interchangeable with TRC-88	3 slant wire antennas: 28, 40, and 57 ft 2-wire counterpoise 50 ft long Interchangeable with TRC-88
6 be nged with g-in stals	5-6	455 kc	4	Yes on 12 v system	Rechargeable Voltage: 12 v Capacity: 14 ah Receiving current: 16 ma Transmitting current: 2-3.7 a Charge time: 4 hr using AC charger; 2 hr using DC charger (24 v) Weight: 10 lb Has 12 v external terminals for auxiliary equipment Interchangeable with 77-AM	3 slant-wire antennas: 25, 40, and 57 ft 2-wire counterpoise 50 ft long Interchangeable with 77-AM
6 be nged with g-in stals	3	455 kc	4	No	Rechargeable Voltage: 6 v Capacity: 10 ah Receiving current: 4 ma Transmitting current: 1 a Charge time: 10 hr(has charge meter on front panel) Weight: 17.6 lb Duty cycle: 5-1	3 types: (1) Whip (2) ¼-wave wire with counterpoise (3) ½-wave wire; use on 4 Mc only
es to c incre-ts from 2 12 Mc	2.7 at 3 db 3 at 6 db	1750 kc 3250 kc (upper or lower frequency)	3	No	Rechargeable 2 types: (1) Voltage: 12 v Capacity: 4 ah Charge time: 24 hr at ¼ ah Weight: 7 lb (2) Voltage: 12 v Capacity: 14 ah Charge time: 4 hr at 5 ah Weight: 12 lb	4 slant-wire antennas: 19, 31, 43, and 63 ft 80-ft counterpoise wire Dipole output at 72 ohms provided
tinuous kc incre-ts	35	11.5 Mc	2	Yes on 24 v system	Dry, disposable Voltage: 2 types (1) 0 + 3 + 15 v with DC-to-DC converter (2) +3 + 15 + 150 v Capacity: 20 ah Weight: 3 lb 12 oz (HV type) Duty cycle: 9-1	Whips, 3 and 10 ft 3-ft whip interchangeable with PRC-35 antenna whips
4 possible 50-kc rements h crys-s	40	10 Mc	3	No	Dry, disposable Voltage: 26 v Capacity: 10 ah Weight: 1.25 lb Duty cycle: 9-1	Steel-tape whip, 3 ft 2 types: (1) One has flexible base (2) Other does not Both interchangeable with 3-ft whip on PRC-25
tinuous ing	--	--	8	No	Dry, disposable Voltage: -6 + 1.5 + 67.5 + 135 v	2 types: (1) Steel-tape short whip (2) Long whip

Operators were relied upon to manually record received messages. In all cases the score was tabulated from the observations of single operators on 8-hour shifts. Also, operators were used to modulate the transmitters. It is recognized that inaccuracies can occur in the results of tests using such gross manual techniques. Time did not permit the accumulation of gear required to use pre-recorded test messages designed to simulate the conditions of military message structures and to tape record received signals for later evaluation by listening teams.

In an attempt to keep test conditions as constant as possible, an attempt was made to carry out each test sequence with the operators in an environment that was consistent and as pleasant as possible. Field representatives from the manufacturers of the various radio sets were requested to be absent while actual tests were being accomplished. Visitors were asked to review the results between test sequences. Changes were not permitted in the test crews during a sequence. The test sequences were so adjusted that there was adequate time to properly conduct the test and to make antenna changes and tuning adjustments with reasonable care. These precautions at least minimized the problem of human interpretation of received signals in noise.

While the receiver operator did not know the contents of the test message, he was well aware of the use of a ten-digit group and knew he was to listen at a specific time.

Laboratory facilities to measure characteristics of set performance such as receiver sensitivity, receiver bandwidth, power output, modulation index, antenna patterns, antenna VSWR, etc. were not available at the beginning of the test series. Consequently, the sets were unpacked, inspected, checked for general performance, and then placed directly into the test series.

The general capability of test personnel was high, and they were familiar with many kinds of communication gear. This was however their first experience with man-pack sets.

A field service representative from Hughes Aircraft for the HC-162

arrived several days before the test series began. In fact, he arrived several days before the HC-162 radio sets, and participated in the establishment of a temporary service and repair center in Bangkok. A representative from the Sylvania Corporation for the AN/TRC-77 and -88 sets arrived during the test sequence. Both representatives were capable and experienced in the maintenance of their radio sets. Both visited the field site area between tests, provided helpful information on the operation of their sets, and promptly corrected maintenance problems.

Operating frequencies employed are listed below.

AN/TRC-77	3.567 Mc
AN/TRC-88	3.567 Mc
TRP-4	3.570 Mc
HC-162	3.575 Mc
AN/PRC-10	40 Mc
AN/PRC-23	40 Mc

The VHF sets employed in the test (AN/PRC-10 and -25) were designed as line-of-sight communication equipments; consequently they could not be expected to operate over the ranges used by the HF sets. Quarter-wave whip antennas were installed on the end of 30-foot bamboo masts to elevate and extend the range of the VHF sets. To further improve their range, the bamboo masts were lashed to the tops of trees, resulting in a whip elevation of about 70 feet. RG59/U coaxial cable was used to connect the whip to the radio sets. One whip was used for all VHF sets at a site.

IV TEST RESULTS

A. General

Test comparing the performance of selected man-pack radios were conducted at ranges of approximately 5, 10, and 22 miles. The capability of each set to handle a brief random message was checked every hour or every second hour of a 24-hour period. The log sheets were examined after the completion of the test series to compare the received message with the transmitted message. The total number of numbers received correctly for each trial is shown in the score sheets. Thus, if seven were correctly received out of the ten transmitted, then a score of 7 is shown. If all ten were received, then a score of 10 is shown. A zero indicates that no message was received or that all numbers were wrong. Occasionally, a set was not used during a portion of the test due to battery replacement or other problems not related to the radio sets. These periods are shown in the score sheets as horizontal lines.

B. Test Results at 5 Miles

TABLE II

SCORE SHEET FOR 5-MILE TESTS

Site 0 Receiving

Local Time		AN/TRC-77		AN/TRC-88		TRP-4		HC-162	
		D*	S**	D	S	D	S	D	S
0900	12 Mar	10	10	9	10	9	8	-	-
1100		10	10	10	10	10	10	-	-
1300		10	10	10	10	10	10	-	-
1500		9	10	0	0	0	0	-	-
1700		10	10	0	9	10	9	-	-
1900		0	0	0	0	0	0	-	-
2100		0	0	0	0	0	0	10	10
2300		10	10	0	0	0	0	9	9
0100	13 Mar	0	0	0	0	0	0	10	8
0300		0	0	0	0	0	0	10	10
0500		-	-	-	-	-	-	-	-
0700		10	9	0	0	0	0	10	10
0900		10	9	10	10	10	10	10	10
1100		10	10	10	10	10	10	10	10
1300		10	10	10	10	10	10	9	10
1500		10	9	10	9	10	10	10	10

*Doublet antenna.
**Slant-wire antenna.

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TABLE II Continued

SCORE SHEET FOR 5-MILE TESTS
Site 0 Receiving

Local Time		AN/TRC-77		AN/TRC-88		TRP-4		HC-162	
		D	S	D	S	D	S	D	S
1200	14 Mar	10	9	10	10	10	10	9	9
1300		10	10	10	9	10	10	9	10
1400		10	10	10	10	10	10	10	10
1500		9	9	9	9	10	9	-	-
1600		10	10	10	8	9	8	8	10
1700		10	9	9	10	10	8	10	10
1800		0	0	0	0	0	0	10	8
1900		0	0	0	0	0	0	0	0
2000		0	0	0	0	0	0	10	10
2100		0	0	0	0	0	0	10	10
2200		0	0	0	0	0	0	10	10
2300		0	0	0	0	0	0	10	10
2400		0	0	0	0	0	0	9	10
0100	15 Mar	0	0	0	0	0	0	10	9
0200		0	0	0	0	0	0	10	10
0300		0	0	0	0	0	0	10	10
0400		0	0	0	0	0	0	10	10
0500		0	0	0	0	0	0	10	9
0600		-	-	-	-	-	-	9	10
0700		9	10	9	9	10	10	9	10
0800		10	10	9	10	10	10	10	10
0900		10	10	10	10	10	10	10	10
1000		10	10	10	10	10	10	10	10
1100		10	10	10	10	10	10	10	10

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TABLE II Continued

SCORE SHEET FOR 5-MILE TESTS
Site 1 Receiving

Local Time		AN/TRC-77		AN/TRC-88		TRP 4		HC-162	
		D	S	D	S	D	S	D	S
0900	12 Mar	10	10	10	10	10	10	-	-
1100		10	10	10	10	10	10	-	-
1300		9	10	10	9	8	9	-	-
1500		10	10	0	0	0	0	-	-
1700		10	10	0	10	8	7	-	-
1900		0	0	0	0	0	0	-	-
2100		0	0	0	0	0	0	10	10
2300		10	0	0	0	0	0	10	10
0100	13 Mar	0	0	0	0	0	0	10	8
0300		0	0	0	0	0	0	10	9
0500		-	-	-	-	-	-	-	-
0700		10	10	0	0	0	0	8	7
0900		10	10	10	10	10	10	5	10
1100		10	10	10	10	10	10	10	9
1300		10	10	10	10	10	10	10	10
1500		10	10	10	10	10	10	10	10

JCP-1, DPG

TABLE II Continued

SCORE SHEET FOR 5-MILE TESTS
Site 1 Receiving

Local Time	AN/TRC-77		AN/TRC-88		TRP-4		HC-162	
	D	S	D	S	D	S	D	S
1200 14 Mar	10	10	10	10	0	10	10	9
1300	7	10	7	10	10	10	10	10
1400	9	10	9	10	10	9	10	10
1500	7	9	7	9	9	10	-	-
1600	10	10	10	10	9	10	9	10
1700	0	0	10	10	10	8	10	10
1800	0	0	0	0	0	0	10	10
1900	0	0	0	0	0	0	10	0
2000	0	0	0	0	0	0	10	10
2100	0	0	0	0	0	0	10	9
2200	0	0	0	0	0	0	10	10
2300	0	0	0	0	0	0	10	10
2400	0	0	0	0	0	0	10	10
0100 15 Mar	0	0	0	0	0	0	10	10
0200	0	0	0	0	0	0	10	10
0300	0	0	0	0	0	0	10	9
0400	0	0	0	0	0	0	8	7
0500	0	0	0	0	0	0	10	9
0600	0	0	0	0	0	0	10	10
0700	10	10	10	10	10	10	10	10
0800	9	7	10	8	10	9	10	10
0900	10	8	10	8	9	10	10	8
1000	10	10	10	9	10	10	10	10
1100	10	10	10	7	10	10	10	10

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TABLE III

SUMMARY OF 5-MILE TESTS

	AN/TRC-77		AN/TRC-88		TRP-4		HC-162	
	D	S	D	S	D	S	D	S
Site 0 Receiving								
Total Messages	390	380	380	380	380	380	320	320
No. Correct	217	214	175	183	188	182	301	302
% Correct	57%	56%	46%	48%	49%	48%	94%	94%
Site 1 Receiving								
Total Messages	390	390	390	390	390	390	320	320
No. Correct	201	194	173	180	173	182	310	294
% Correct	52%	50%	44%	46%	44%	47%	97%	92%

C. Test Results at 10 Miles

TABLE IV

SCORE SHEET FOR 10-MILE TESTS
Site 0 Receiving

Local Time		AN/TRC-77		AN/TRC-88		TRP-4		HC-162	
		D	S	D	S	D	S	D	S
1100	26 Mar	10	10	10	10	10	10	10	10
1300		10	10	10	10	10	10	10	10
1500		8	9	9	6	10	8	6	0
1700		10	8	8	8	8	9	10	10
1900		6	0	2	0	9	0	10	10
2100		0	0	0	0	8	0	10	10
2300		0	0	0	0	0	0	0	0
0100	27 Mar	0	0	0	0	10	0	10	10
0300		0	0	8	0	10	0	8	10
0500		0	0	0	0	0	0	10	0
0700		0	0	10	8	9	6	10	10
0900		10	9	10	10	10	9	10	10
1100		10	10	10	10	10	10	10	10
1300		10	10	10	10	10	10	10	10
1500		0	0	0	0	10	7	10	9
1700		6	5	9	9	7	0	10	0
1900		0	0	0	0	9	0	10	10
2100		0	0	0	0	0	0	10	10
2300		0	0	0	0	0	0	10	10
0100	28 Mar	0	0	0	0	0	0	0	0
0300		0	0	9	0	10	0	10	10
0500		0	0	0	0	0	0	10	0
0700		10	10	10	10	10	8	10	10
0900		9	10	10	10	10	10	10	10

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TABLE IV Continued

SCORE SHEET FOR 10-MILE TESTS
Site 2 Receiving

Local Time		AN/TRC-77		AN/TRC-88		TRP-4		HC-162	
		D	S	D	S	D	S	D	S
1100	26 Mar	10	10	10	8	10	10	10	10
1300		9	10	10	5	10	5	9	10
1500		9	8	8	6	10	2	10	0
1700		10	9	10	10	10	10	10	9
1900		0	0	0	0	10	0	8	10
2100		0	0	0	0	9	0	10	8
2300		0	0	0	0	0	0	0	0
0100	27 Mar	0	0	7	0	5	0	9	5
0300		0	0	9	0	9	0	10	7
0500		0	0	0	0	0	0	7	0
0700		0	0	9	9	10	9	10	9
0900		10	10	10	6	10	10	10	10
1100		10	10	10	7	10	9	10	10
1300		10	10	9	9	10	10	10	10
1500		0	0	0	0	10	8	10	10
1700		5	7	8	8	7	0	10	0
1900		0	0	0	0	9	0	10	10
2100		0	0	0	0	0	0	10	10
2300		0	0	0	0	0	0	10	10
0100	28 Mar	0	0	0	0	0	0	0	0
0300		0	0	10	0	9	0	10	10
0500		0	0	0	0	0	0	8	0
0700		10	7	10	10	10	10	10	10
0900		10	10	10	10	10	10	10	10

JCP-1, DPG

TABLE V

SUMMARY OF 10-MILE TESTS

	AN/TRC-77		AN/TRC-88		TRP-4		HC-162	
	D	S	D	S	D	S	D	S
Site 0 Receiving								
Total Messages	240	240	240	240	240	240	240	240
No. Correct	99	91	125	101	170	97	214	179
% Correct	41%	38%	52%	42%	71%	40%	89%	75%
Site 2 Receiving								
Total Messages	240	240	240	240	240	240	240	240
No. Correct	93	91	130	88	168	93	211	168
% Correct	39%	38%	54%	35%	70%	39%	88%	70%

JCP-1, DPG

D. Test Results at 22 Miles

TABLE VI

SCORE SHEET FOR 22-MILE TESTS
Site 0 Receiving

Local Time		AN/TRC-77		AN/TRC-88		TRP-4		HC-162	
		D	S	D	S	D	S	D	S
1100	19 Mar	10	2	0	0	10	0	9	0
1300		10	9	0	0	10	9	10	10
1500		10	8	0	0	10	0	9	7
1700		9	8	10	0	10	0	10	7
1900		0	0	0	0	0	0	7	0
2100		0	0	0	0	0	0	9	0
2300		0	0	0	0	0	0	10	10
0100	20 Mar	0	0	0	0	0	0	10	10
0300		0	0	0	0	0	0	0	0
0500		0	0	0	0	0	0	0	0
0700		0	0	0	0	10	0	10	4
0900		9	10	10	10	10	7	10	8
1100		10	3	10	0	10	0	10	0
1300		10	0	10	0	10	0	10	0
1500		10	10	9	0	10	5	10	8
1700		10	10	10	10	10	10	10	10
1900		9	0	10	0	10	0	10	10
2100		0	0	8	0	10	0	10	0
2300		10	0	0	0	9	0	10	10
0100	21 Mar	0	0	0	0	10	0	10	7
0300		6	0	7	0	10	0	10	10
0500		0	0	0	0	0	0	0	0
0700		10	10	10	7	10	9	10	0
0900		10	7	10	8	10	10	10	10

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TABLE VI Continued

SCORE SHEET FOR 22-MILE TESTS
Site 3 Receiving

Local Time		AN/TRC-77		AN/TRC-88		TRP-4		HC-162	
		D	S	D	S	D	S	D	S
1100	19 Mar	10	10	0	0	10	0	10	10
1300		8	9	0	0	10	0	10	10
1500		8	10	0	0	0	0	10	10
1700		9	10	6	9	8	0	10	10
1900		0	0	0	0	0	0	9	0
2100		0	0	0	0	0	0	10	0
2300		0	0	0	0	0	0	9	9
0100	20 Mar	0	0	0	0	0	0	10	10
0300		0	0	0	0	0	0	0	0
0500		0	0	0	0	0	0	0	0
0700		0	0	0	0	0	0	10	10
0900		10	10	10	10	8	10	10	10
1100		10	9	10	0	10	0	10	0
1300		10	0	10	0	10	0	10	0
1500		7	10	10	0	9	7	10	9
1700		10	10	10	10	9	10	10	10
1900		10	0	5	0	9	0	6	8
2100		0	0	10	0	9	0	10	0
2300		10	0	0	0	10	0	10	10
0100	21 Mar	0	0	0	0	9	0	10	10
0300		9	0	7	0	9	0	10	10
0500		0	0	0	0	0	0	0	0
0700		10	9	10	9	10	10	10	10
0900		10	8	10	9	10	10	10	10

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TABLE VII

SUMMARY OF 22-MILE TESTS

	AN/TRC-77		AN/TRC-88		TRP-4		HC-162	
	D	S	D	S	D	S	D	S
Site 0 Receiving								
Total Messages	240	240	240	240	240	240	240	240
No. Correct	133	77	104	35	169	50	204	121
% Correct	55%	32%	43%	15%	70%	21%	85%	50%
Site 3 Receiving								
Total Messages	240	240	240	240	240	240	240	240
No. Correct	131	95	98	47	140	47	204	156
% Correct	55%	40%	41%	20%	58%	20%	85%	65%

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E. Histograms Showing Variation in Results with Time of Day

An examination of the score sheets shows a definite trend toward communications failure during the early morning hours on all tests. To better examine this trend, the score for all tests was totaled for each test period and plotted as a histogram in Figs. 4 through 6. Test periods where incomplete data were accumulated have been ignored.

The histograms clearly show a diurnal effect. Special tests conducted during non-test periods have convinced the author that failures in performance during the nightime are related to normal ionospheric changes which change propagation conditions. These changes can cause significant increases in interference levels during evening and night hours due to the removal of D-region absorption from the interference path geometry. Also, the normal nightime decrease in the maximum propagating frequency was observed to fall below the lowest frequency available on the sets during early morning hours.

A close examination of the performance of the HC-162 set reveals that it contributes heavily to the nightime portion of the histogram records. During the period of approximately 0100 through 0500, the HC-162 sets frequently received high scores, although the signal strength was very weak. The nature of the tests and the lack of specialized propagation instrumentation made it impossible to identify with certainty the nature of the weak path sometimes available and useful to the HC-162 during early morning hours.

F. Interference Test Results

Severe interference was common during all tests, causing some inaccuracy and variation in the test results given in this memorandum. Neither equipment or techniques were available to adequately record or describe the effects of interference on the test results. The ever-changing character of interfering signals made it almost impossible to evaluate on the spot their effect on a particular test, and adequate time was not available during a test series to identify and make notes on specific causes of interference.

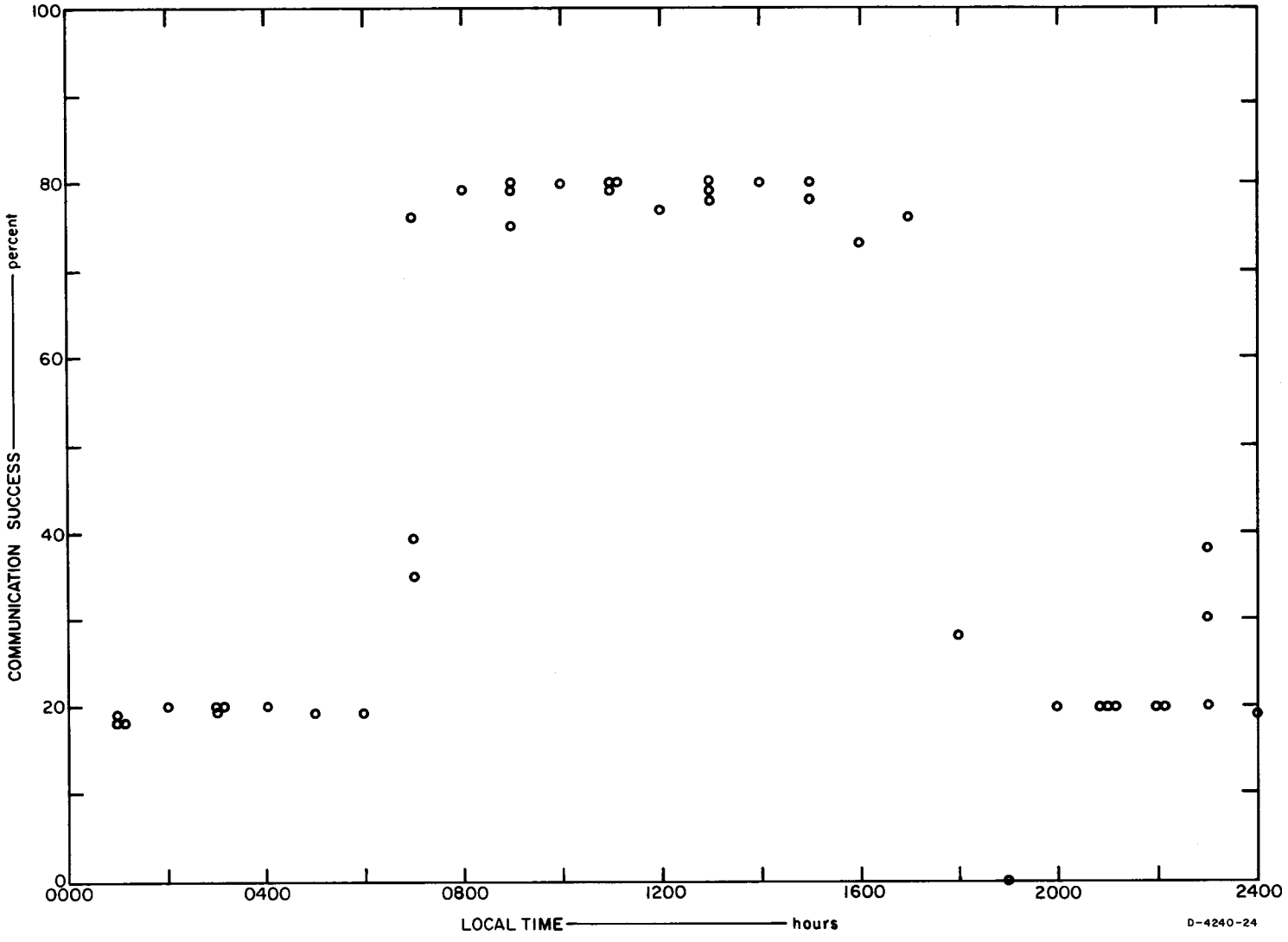

FIG. 4 HISTOGRAM SHOWING COMMUNICATION SUCCESS vs. TIME OF DAY – 5-MILE FOREST TESTS

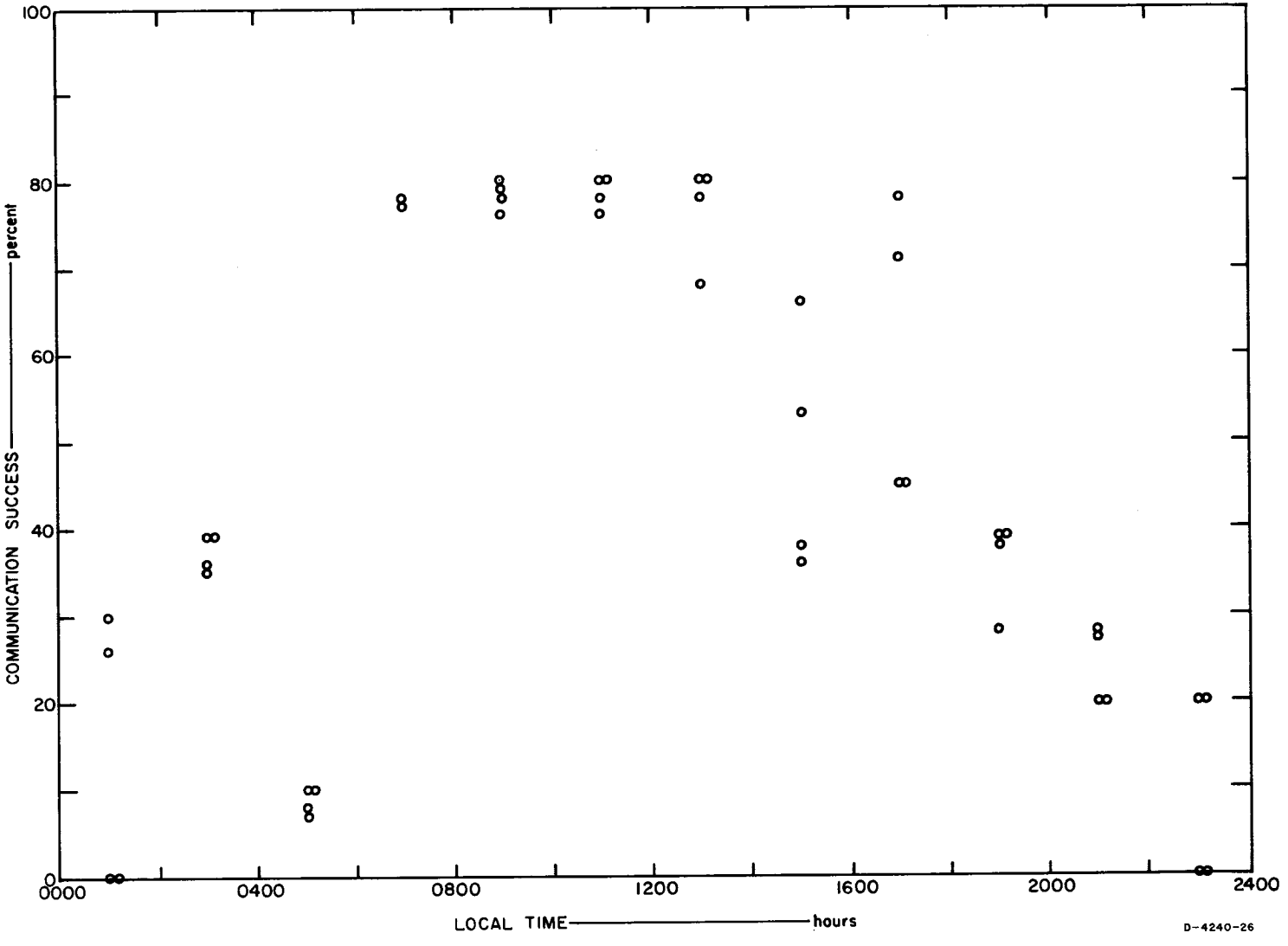

FIG. 5 HISTOGRAM SHOWING COMMUNICATION SUCCESS vs. TIME OF DAY – 10-MILE FOREST TESTS

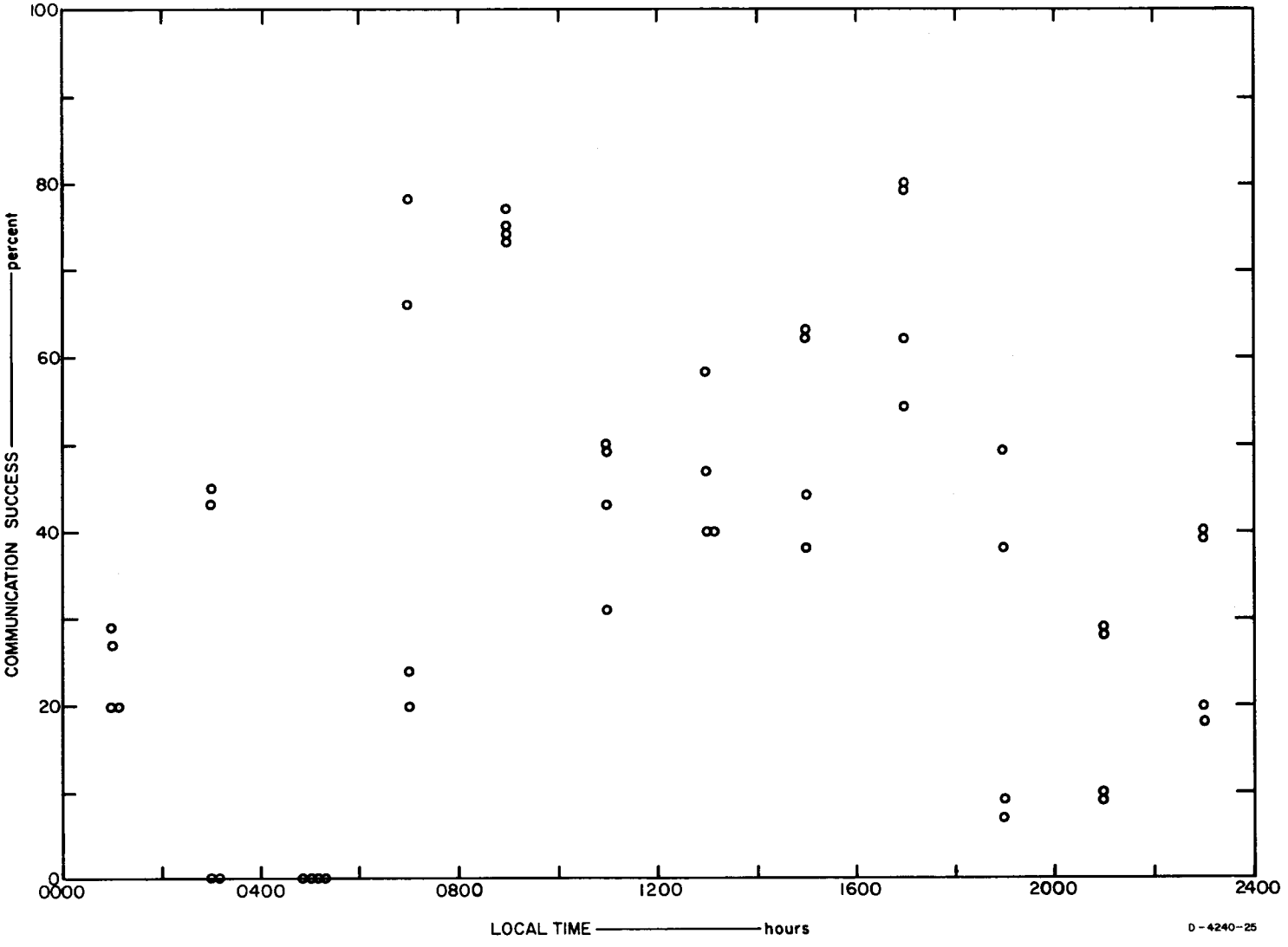

FIG. 6 HISTOGRAM SHOWING COMMUNICATION SUCCESS vs. TIME OF DAY – 22-MILE FOREST TESTS

Several special tests were conducted on interference during periods between test series. The HC-162 1-kc tuning steps proved to be a useful tool in dodging interference.

The effect of interference on the limited number of channels of the AN/TRC-77, AN/TRC-88, and TRP-4 sets is the reduction of channels available for successful communication. Brief samples were made on the signals noted in the channels of an AN/TRC-77. The observations of one evening are summarized as follows:

Local Time	Channel	Comments
2100	1	Strong carrier with no modulation.
	2	Modulation splatter from adjacent channel.
	3	Broadcast station.
	4	Several stations, all strong.
	5	Weak CW signals.
	6	Broadcast station, speech.
2145	1	Static--no interference.
	2	Static and popping noise--no interference.
	3	Music.
	4	CW station.
	5	Static--no interference.
	6	Strong carrier signal with no modulation.
2323	1	Hissing noise--no interference.
	2	Music.
	3	Music.
	4	Weak static--no interference.
	5	Modulation of interfering signal not identified.
	6	Garbled voice signal.

At 2100 only Channel 5 was usable. Forty-five minutes later, Channels 1, 2, and 5 were free of interference. Approximately 2 hours later Channel 1 and 4 were free of interference. None of the interfering signals was of local origin, and all were identified as signals propagated via sky wave from distant sources. In view of the varying ability of the ionosphere to propagate interference, the unknown lobe structures of field antennas, and other factors, it does not seem possible to select interference-free channels. The AN/TRC-77, AN/TRC-88, and TRP-4 radio sets provide only one or two effective channels, because interference limits their channel availability. Table VIII lists the channel frequencies used by the AN/TRC-77, AN/TRC 88, and TRP-4.

TABLE VIII

CHANNEL FREQUENCIES
USED BY AN/TRC-77, AN/TRC-88, AND TRP-4

Channel No.	AN/TRC-77 & AN/TRC-88	TRP-4
	(Mc)	(Mc)
1	3.567	2.527
2	4.887	3.570
3	4.908	4.892
4	5.465	5.468
5	6.505	6.507
6	7.362	7.363

G. VHF Test Results

Due to the line-of-sight propagation characteristics of the VHF sets, test procedures for them were somewhat different from those for the HF sets. The VHF sets were used in direct competition with the HF sets on the 5-mile range, with excellent success. It was, however, necessary to increase the antenna height to about 70 feet at each terminal.

During short-range special tests, it was found very advantageous to elevate the base-station antenna. Significant range increases were noted when both 30- and 70-foot base-station antenna heights were used.

Of course the higher antenna always outperformed the lower.

Use of a base-station antenna height of 30 feet resulted in about 3 miles of reliable range when communicating with a man-pack unit, even in moderate to dense undergrowth. In one case, however, an area was found where communication failed at less than one-half mile. The terrain was generally flat, but the undergrowth between the base station and the backpack unit can be described as truly formidable. Penetration of this area by man was impossible, because of the extremely dense growth.

V DISCUSSION AND SUMMARY OF TEST RESULTS

A. HF Test Results

The HF tests were made using the AN/TRC-77, AN/TRC-88, TRP-4, and HC-162 radio sets. Several interesting and pertinent observations were made from the test results and from the conduct of the tests. Some of the comments that follow are based upon special tests conducted by the author and the field crew to better acquaint themselves with the general capabilities of the man-pack sets under test.

1. Propagation Modes

Propagation via the ionosphere was the major mode observed on all tests. No ground wave signal could be identified even at 5-mile separation. Shorter ranges were not investigated.

2. Possibility of Interference-Free Channels

The HF spectrum is very crowded in Southeast Asia. From the tests conducted, it appears impossible to obtain interference-free channels. While it might be possible to obtain a clear channel in Thailand, most of the interference originates in neighboring countries. No means of coordination with these countries exists to set up interference-free channels for test purposes. (See Sec. IV-F.)

3. Usability of Prediction Techniques

Radio prediction techniques such as those developed and used by the United States Army Propagation Agency apply to man-pack radio sets and can be used to predict their performance.

4. Antennas

A doublet antenna outperformed the slant-wire antenna even though the feed line for the doublet was improperly matched.

Unknown antenna patterns for the slant wire and low dipole prohibited the computation of received signal-to-noise ratios. The establishment of even gross antenna radiation characteristics would

permit the computation of received signal-to-noise ratios and shed light on ways to improve the desired signal-to-interference ratio.

See Sec. 5 for comment on HC-162 antenna mechanism.

5. HC-162

The frequency flexibility of the HC-162 set proved of significant value in establishing communications. Usually an adequately free channel could be found by either lowering or raising the operating frequency by 1 or 2 kc.

The HC-162 set clearly had a signal readability advantage over the other sets. Its higher power output and narrower receiver IF bandwidth provided a definite increase in signal readability. Undoubtedly, the narrower received bandwidth also resulted in less interference in the receiver output.

The antenna tuning mechanism of the HC-162 is unduly complicated and difficult to adjust. It has three controls which interact compared to two controls which do not interact for the other sets. The complicated antenna tuning of the HC-162 set requires an increased time factor of three to five for tuning when compared to the other sets. This results in battery power being wasted while the antenna is being tuned.

6. AN/TRC-77 and -88

The AN/TRC-77 and -88 sets were simple and easy to operate, compared to the HC-162.

B. VHF Test Results

The VHF tests were made using the AN/PRC-10 and -25 sets.

1. Use of Antennas

Both the AN/PRC-10 and -25 sets generally worked well at ranges up to 3 miles in moderate forest areas, using their long whip antennas.

Elevation of one or both whip antennas above ground gave decided range improvements. With both whip antennas 70 feet above the ground, lashed to the tops of trees, 5-mile range was established 24

hours a day. With both antennas elevated only 30 feet above ground, 5-mile communication through moderate forest could not be established.

On one test conducted through extremely dense undergrowth, with a long whip on the base station set and a short or long whip on a hand-carried set, total loss of signal occurred at less than one-half mile range. Only one such location was found in the test area.

2. Comparison of AN/PRC-10 and -25

Little difference could be found between the capability of an AN PRC 25 and an AN PRC-10 to establish a useful voice channel. No range difference was noted.

The AN/PRC-10 did drift in tuning with time. This resulted in speech distortion which was corrected by occasional retuning. Drift rate tests on several units would be required to establish the magnitude of this problem.

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